MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

INTRODUCTION

Missouri is blessed with an abundance of water resources, native forests, biologically-diverse rivers and streams, and large reservoirs that provide hydroelectric power, public water supplies, and recreational opportunities for our citizens. River drainage in Missouri is either directly or indirectly to the Mississippi River, which forms the eastern boundary of the state. The Missouri River flows eastward across the state from Kansas City, entering the Mississippi River just above St. Louis. Most of northern Missouri is drained by tributaries to the Missouri River including the Grand, Chariton, One Hundred and Two, and Nodaway rivers. Principal southern tributaries to the Missouri River are the Osage and the Gasconade rivers. Important tributaries which drain directly into the Mississippi River are the Fox, Wyaconda, Fabius, and Salt rivers in the northeast, and the Meramec River which enters the Mississippi River below its confluence with the Missouri River. A small portion of the southwest corner of the state lies in the headwater area of several Arkansas River tributaries. A relatively small area in the south and southeast drains directly into the Mississippi River outside the state through the White, St. Francis, and other small river systems (Decker 2014). Large reservoirs in Missouri include the Lake of the Ozarks, Truman Reservoir, Mark Twain Lake, Table Rock Lake, and Lake Taneycomo. However, these water resources have also experienced decades of significant increases in nutrient pollution and nutrient-related impairments to beneficial uses as land development has expanded and our population has grown.

Missouri's geography is extremely diverse. The northern part of the state lies in the dissected till plains, while the southern part lies in the Ozarks Plateau, with the Missouri River dividing these two regions. Northern Missouri was formed by several different glaciation periods. However, glaciation advancement and the dissected till plains region ended at the Missouri River. The largest physiographic region of Missouri is the Ozarks Plateau, which includes the Springfield Plateau, located in southwest Missouri, and the Salem Plateau comprising most of southern Missouri. Within the Salem Plateau lies the St. Francois Mountains which includes the highest natural point in Missouri, Taum Sauk Mountain, at 1,772 feet. The Bootheel region in southeast Missouri is located within the Mississippi Alluvial Plain, which was formed from flooding of the Mississippi River. Each physiographic region in Missouri is associated with different soils. Claypan soils are found from southwest to northeast Missouri and were historically associated with deciduous forests. Karst soils are highly weathered soils that are located throughout the Ozarks Plateau. This unique topography has produced numerous caves and many large springs, as well as losing streams. The Ozarks Plateau has many large, clear freshwater springs such as Big, Greer, Alley, Round, Bennett and Montauk, Maramec; and Welch and Blue in the Current River. The deep rich soils of the Bootheel area in southeast Missouri are typical of soils found in wetland habitats and this region has been developed into the most intensive agricultural area of the state. The various physiographic regions in Missouri support a wide variety of agricultural uses and cropping practices. Corn and soybeans are the principal crops grown throughout the state. However, wheat is often intercropped with corn and soybeans, and rice and cotton are grown regionally in the Bootheel area. Missouri has a large livestock industry and large amounts of pastureland are present throughout the state with thousands of acres hayed annually. Corn, soybeans, cattle, hogs, and turkeys are Missouri’s leading agricultural products with livestock accounting for more than half of the state’s agricultural receipts. Missouri generally ranks in the top ten nationally in rice, soybean, cotton,

grain sorghum and corn production and it ranks second in the number of farms. The lumber industry in Missouri has always been prominent and hardwoods are harvested throughout the entire state. Numerous minerals have also been excavated. Missouri's lead mining was very prominent in the past and significantly contributed to the U.S. lead market. Coal, crushed stone, gravel, clay, iron oxide, zinc, and barite are also extracted.

Average annual temperatures and precipitation in Missouri range from 50 degrees and 34 inches, respectively, in the northwest to 60 degrees and 50 inches in the southeast. Missouri is ranked 18th nationally in population and is comprised of 114 counties and the independent city of St. Louis. The four largest urban areas are St. Louis, Kansas City, Springfield, and Columbia. Missouri has a total of 77 cities with a population of 10,000 or greater; however, many areas of the state are characterized by small cities and villages with fewer than 1,000 residents.

During the past 10 years, nutrient pollution has become one of the most important environmental issues in Missouri and throughout the Mississippi River watershed. Localized excess nutrient loads in Missouri adversely affect recreational activities by causing algal blooms and an overabundance of aquatic plants in ponds and reservoirs. In addition, losses of soil, nutrients and organic matter from agricultural lands have significantly reduced soil health and resulted in adverse economic impacts to agricultural producers. In addition, many public drinking water supplies in northern Missouri rely on surface waters as their primary source of drinking water and high nutrient levels that occur after rainfall events often stimulate algal blooms that require enhanced water treatment before the water can be used for human consumption. In addition, the size of the hypoxic zone (dead zone) in the northern Gulf of Mexico has expanded as a result of increasing nitrogen and phosphorus loads which produce favorable conditions for excessive growth of algae. When algae die, the associated organic matter sinks to the bottom where it decomposes, consuming most of the available oxygen. Hypoxia can cause fish to leave the impacted area, and it can kill shellfish and other organisms that are unable to swim out of the hypoxic zone. Not surprisingly, this recurring condition has exerted a devastating economic impact on the regional fishing industry.

During the past century, water resources planning in Missouri has evolved to meet changing needs. Missouri's first state water plan was completed in 1911 and focused on sanitation and wastewater treatment. During the Great Depression, the 1938 state water plan identified over 300 infrastructure projects that provided water resources benefits and job opportunities. Following the passage of the Clean Water Act in 1972, water planning focused primarily on water pollution reduction from point source dischargers. More recently, water protection efforts have focused on development of regional water supplies based on an improved understanding of the uses and availability of Missouri's water resources. In 2011, Missouri renewed its focus on watershed-based planning by implementing the Our Missouri Waters Initiative, which combines planning for water quality and quantity, and it initiated development of this state-level nutrient reduction strategy.

Most people recognize that in order to successfully address environmental concerns, it is important to obtain input and support from local representatives and other experts that understand the unique conditions of their watersheds. The ideas and recommendations that have been shaped through this cooperative interaction between state and federal agencies, municipal

and county organizations, local watershed groups, private industry, agricultural and environmental organizations, farmers, ranchers, and other Missouri residents has resulted in a broad, collaborative strategy that involves shared responsibility. As we've witnessed in other states and in the Great Lakes and Chesapeake Bay watersheds, a balanced approach with shared responsibility usually works best. The Committee has been diligent in its discussions about the many complex nutrient issues that exist in Missouri and steadfast in developing reasonable cost-effective nutrient reduction strategies. It will likewise be important for all Missouri citizens to be diligent and engaged in implementing as many of the recommended nutrient strategies as possible, so that collectively over time, our actions can produce significant reductions in nutrient loads, cleaner streams and lakes in Missouri, and improved water quality in the Gulf of Mexico.

Clean water is vital to Missouri's economy and nutrient loading presents a diverse set of challenges. It is clear that additional efforts are needed to reduce nutrient loading to Missouri's lakes and streams and must involve many diverse sectors of Missouri's economy: farmers, agri-business, industry, trade associations, municipal and county governments, environmental groups, and the public. Working with representatives from all of these sectors, Missouri needs to find cost-effective and economically-sustainable ways to reduce discharges of excessive nutrients in point source effluents and nonpoint source runoff of nutrients from urban and agricultural lands. An important key to our success will be collaboration to increase our efficiencies and effectiveness by working together and sharing resources. During runoff events, peak nutrient loads are flushed through small streams and rivers and reach lake ecosystems where excessive nutrient levels can result in harmful algae blooms, increased water treatment costs, and in some cases public health concerns. Meeting global food demands in a sustainable manner, providing for economic growth in cities and towns, and protecting water quality poses significant challenges. These challenges are best met through the development of new technologies and practices, promoting increased awareness of best management practices, continued scientific research and developing greater understanding of the effectiveness of various approaches to reduce nutrients entering our waterways.

The purposes of this document are to describe the current state of knowledge about nutrient loading in Missouri and to describe broadly-agreed upon strategies for reducing nutrient loads. The Missouri Nutrient Loss Reduction Strategy was developed over a three-year period from October 2011 through September 2014 using a federal Gulf of Mexico Section 104(b)(3) grant and existing state, federal, local, and private resources. Implementation of the nutrient loss reduction strategies in this document will be accomplished through partnerships that leverage state and local resources with federal resources and market-based funding opportunities. An example of these federal, state, and local partnerships is the Mississippi River Basin Healthy Watersheds Initiative (MRBI), which has been an important tool in reducing nutrient and sediment runoff in Missouri. From 2010-2013, Missouri applied for and received funding for more watershed projects through the MRBI Cooperative Conservation Partnership Initiative (CCPI) of the U.S. Department of Agriculture (USDA) – Natural Resource Conservation Service (NRCS) than any of the other 12 states in the Mississippi River Basin that were eligible to submit applications.

It is well-documented that nutrients, such as nitrogen and phosphorous, can lead to increased production of algae and aquatic plants in freshwater systems. This increased

production may result in nonattainment of beneficial uses under certain environmental conditions. Aquatic life uses can be impacted by nutrient loading, which increases the likelihood of fish kills due to dissolved oxygen depletion and undermines aquatic diversity by creating conditions favorable to fast growing species, such as carp and benthivores, at the expense of other species (Edgertson and Downing, 2004). Water quality issues in drinking water supplies are frequently attributed to specific species of algae that produce a range of toxicity and result in taste and odor problems, as well as risks to human, livestock and wildlife health (Downing et al., 2001). Swimming and other recreational activities may also be impaired or precluded due to reduced water clarity associated with algae growth, which can affect the attractiveness of the water body and prompt safety concerns due to reduced water clarity (Heiskary and Walker, 1988).

In spite of the widespread adoption of agricultural best practices, agricultural operations and activities continue to contribute to nutrient pollution in freshwater and coastal ecosystems. Fertilizers are often applied to crop fields at the wrong time or in amounts that exceed crop needs, resulting in nutrient runoff to water bodies. Some animal feeding operations remain poorly managed or improperly dispose of their manure, allowing it to leach into nearby waterways. In addition, heavy rainfall events and weather variability makes the elimination of nutrient losses from agricultural lands extremely difficult even when BMP's are in place. Similarly, growth in urban populations combined with a lag in funding for infrastructure maintenance and improvements have prevented many communities from adequately addressing their wastewater and storm water needs. Many of Missouri's communities are taking steps to significantly reduce the nutrients they release; however, much more work is needed to eliminate combined sewer outfalls, inflow and infiltration and other problems. These excess nutrients cause massive and sometimes toxic algae blooms that can be detrimental to human health, reduce recreational uses of lakes and reservoirs, cause fish kills, and contribute to the "dead zone" in the Gulf of Mexico. Globally, nutrient pollution of coastal waters has resulted in increased numbers of dead zones from fewer than 25 areas in 1960 to more than 500 hypoxic zones today (World Resources Institute, 2012).

While understanding of the sources of nutrients to waterways has advanced with our understanding of the fate and transport of nutrients (USGS 2013), many significant uncertainties remain in solving the nutrient loading issue. This strategy, therefore, will take an adaptive management approach by focusing on the next five years of implementation and learning to guide actions in subsequent years.

We recognize that the nutrient reduction goals and strategies in this document are ambitious and the tasks ahead of us will be challenging. These challenges include:

1. State, federal, local, and private agencies and organizations have varying missions, goals, objectives, policies, regulations and statutes.
2. Population growth and associated increases in nutrient pollution.
3. Urban sprawl into agricultural areas.
4. Growing more food on the same amount of land for an expanding world population.
5. Maintaining sustainable and productive agricultural systems, while improving soil quality and reducing nutrient runoff.
6. Conversion of Conservation Reserve Program (CRP) land to cropland.

7. Lack of participation in conservation cost-share programs within priority watersheds.
8. Increasing numbers of absentee landowners.
9. Climate change and increases in extreme weather events.
10. Adequate water supplies.
11. Higher fuel costs.
12. Creating jobs while reducing nutrient runoff.

Two of the most significant factors will likely be the predicted growth of both human and livestock populations in Missouri. Expected increases in human population growth will likely result in: increased nutrient loadings to municipal wastewater treatment facilities and onsite wastewater treatment systems; increased use of automobiles and other forms of transportation and associated exhaust emissions; increased energy demands, including burning of fossil fuels, and emissions of nitrogen oxides into the atmosphere; expansion of urban areas (urban sprawl) into agricultural lands due to increased needs for housing, commercial and industrial development areas and associated increases in impervious surfaces, runoff, and accelerated erosion of urban streams. In addition, expansions in cattle, swine, and poultry populations will likely be needed to feed the growing human populations and intensified efforts to properly utilize and manage livestock and poultry manure will be needed. Expansion of agricultural cropland into more erodible lands, possible increases in fertilizer usage in response to higher grain prices and increased demands for food will also be likely. In addition, nutrient loadings from past pollution events (legacy effects) will continue to be recycled within aquatic environments and existing nutrients within soil profiles will continue to infiltrate downward until they eventually reach groundwater and surface waters. Thus, many watersheds in Missouri will likely have increased stresses as Missouri's population exceeds 7.0 million people by 2050. All Missouri citizens contribute to nutrient pollution and we must all do everything we can to reduce our contributions to nutrient loadings, so that collectively over time, our individual contributions will result in significant improvements to the nutrient quality of surface waters and groundwater in Missouri. A section of this strategy is devoted to things that all of our citizens can do to reduce their nutrient footprints and help improve the quality of Missouri's waters.

The committee established the following guidelines for developing the nutrient reduction actions listed in this strategy:

Vision Statement

"All Missouri waters have acceptable levels of nutrients that maintain water quality for designated uses."

Guiding Principles

1. Solicit participation from a diverse and inclusive group of federal, state, and local agricultural, natural resource, and environmental partners and involve the highest levels of leadership possible.
2. Use best available science to make decisions. Use adaptive management in response to uncertainties and improvements in scientific knowledge.
3. Identify and adopt appropriate nutrient reduction strategies that have been successfully implemented in other states. Modify existing strategies and develop new strategies, as

needed, to address Missouri-specific nutrient issues. Develop strategies that address water quality protection and eliminate impairment.

4. Develop a balanced set of management tools. Effective nutrient reduction strategies require protective laws and regulations, broad-based public education, and cost-share and technical assistance programs.
5. Develop nutrient reduction strategies for nonpoint source sources that are voluntary, incentive-based, and economically-sustainable. Effective incentives and methods of cooperation generally include cost-share and peer influence.
6. Develop strategies that focus on addressing the underlying causes of nutrient pollution problems rather than treating symptoms. If causes are not addressed, problems and symptoms will persist. Focus on strategies that also provide secondary benefits.
7. Implement point and nonpoint source nutrient reduction strategies in parallel and through existing programs. Identify the costs of nutrient reduction strategies in terms of cost/pound of pollutant removed. Develop strategies that provide the greatest benefits at the least cost.
8. Identify available funding, additional funding needs, potential funding sources, and market-based opportunities. Develop strategies that maximize leveraging of existing federal, state, and local resources.
9. Establish clear, comprehensive, and quantifiable goals and indicators of progress. Publicize and communicate nutrient reduction strategy recommendations. Measuring progress and publicizing results are important in maintaining leadership commitments and public support. Conduct regular reassessments of goals and strategies by reviewing water quality monitoring data, modeling results, and other measures of success.
10. Evaluate nutrient reduction strategies on a small watershed scale using demonstration or pilot projects before applying them to larger regions.

Many of the nutrient reduction strategies listed in this document are accompanied by quotations from one of Missouri's most well-known citizens, Samuel Langhorne Clemens, who is better known as Mark Twain. Look for these famous quotations as you read the recommended nutrient reduction strategies in this document. As Mark Twain once said, ***"Thunder is good, thunder is impressive; but it is the lightning that does the work."*** We are hopeful that the recommendations read from this document won't just make noise, but upon their implementation, significant reductions in nutrient loadings will occur to Missouri's surface waters and groundwater. Mark Twain also said, ***"Courage is resistance to fear, mastery of fear, not absence of fear."*** In order to address these problems, it will be important for Missourians to have the courage to change many of our past habits and practices and to try the new management practices and techniques recommended in this document. Many of these new practices and techniques may require some additional financial commitments; however, these recommendations have been based on sound scientific principles and research that have been successful in Missouri and other states. The Committee is optimistic that implementation of the recommended nutrient reduction strategies through the collective efforts of all Missouri citizens will significantly reduce nutrient loads throughout the state and help reduce nutrient loads to the Gulf of Mexico.

Our next steps will be to select the watersheds that will place the strategy into action and generate measurable results. These recommendations will be implemented through the Our Missouri Waters Initiative of the Missouri Department of Natural Resources and through existing

federal, state, and local programs. During this crucial phase, our partnerships will expand even further to involve the people of local communities, businesses, and other stakeholders that have a vested interest in the future of local water resources. Some of the statewide priorities and strategies will include opening up new markets and sources of income for Missouri agriculture and creating new jobs. This will be accomplished in part through development of programs that generate, buy, and sell nutrient credits. However, the focus of most of these recommended strategies will be to support local watershed management plans in reducing excessive nutrient loads that impair local water quality. All of these steps must and will be grounded in the best available science and utilize an adaptive management approach. This strategy will facilitate the long-term vitality of our state through protection and restoration of water quality. As funding becomes available to implement these strategies, we are confident that these measures will restore and protect our water resources for future generations. In addition, the continued collaboration of state and federal agencies and other stakeholders within our local watersheds will be pivotal to the success of these strategies.

This document represents a multi-year effort in which the most knowledgeable and creative Missourians were sought out to provide their opinions and ideas for developing the most practical and effective strategies possible for reducing nutrient pollution in Missouri. This document also represents our commitment as a state to protect and restore Missouri's groundwater and surface water resources so that we can ensure a vibrant environmental and economic future. We are very grateful to all of our committee members for their hard work and dedication in developing these thoughtful, science-based nutrient reduction strategies and we look forward to working together to implement these strategies and to improve Missouri's water quality. We are proud to present our state's nutrient reduction recommendations in this document.

Missouri Nutrient Reduction Strategy Committee